AD-A165 116 THE EFFECT OF SUBMERGED NORFOLK BAR ON WAVE CONDITIONS 1/1
(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION
VICKSBURG MS S A HUGHES 31 MAY 83

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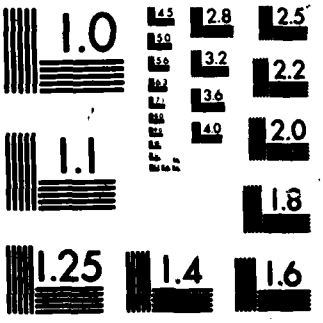

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The purpose of this study was to examine, through use of a mathematical model, the alterations in the wave climate caused by a submerged offshore bar (offshore Virginia Beach/Norfolk). Conclusion was that in all cases a phase lag developed as the wave passed over the bar, resulting in wave refraction around the ends of the bar. The refraction appeared to be relatively minor with little noticable effect on the adjacent shoreline. The estimated bottom velocities at the bar crest are well above those necessary for the initiation of sand transport, and a reworking of the bar material can be expected.

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CERRE-CO 31 May 1983

MEMORANDUM FOR RECORD

SUBJECT: The Effect of the Submerged Norfolk Bar on Wave Conditions

1. PURPOSE. The purpose of this memorandum is to convey the results of studies carried out by the Coastal Oceanography Branch into the alterations in wave climate caused by a submerged bar at Norfolk.

2. METHOD. The DHI System 21, Mark 8 model was used in the short wave mode to examine the wave conditions with and without the submerged bar. This numerical model solves the vertically integrated equations of conservation of volume and momentum (the Saint Venant equation) by implicit finite difference techniques with variables defined on a uniform rectangular grid. In the short wave simulation corrections for the nonhydrostatic pressure distribution due to vertical accelerations are accounted for by including the Boussinesq terms. A regular cnoidal wave was used as input to the model, and no attempt was made to simulate the tidal current flow which might be present near the mouth of the Chesapeake.

3. PARAMETER SELECTION.

a) Bathymetry: The bathymetry for the model was approximated using charts of the region in the vicinity of the bar placement. Over the area being modeled (900 meters by 1200 meters, see Encl. 1) the bottom can be taken as a composite of two uniform slopes (Encl. 2). Based on information furnished by Dr. Weishar of Coastal Processes Branch, the submerged bar was approximated as shown in Encl. 2. The top of the bar was about 7.5 meters below mean low water and the onshore foot of the bar began at the -9m (MLW) contour. The sides of the bar had a slope of 1/111 which was thought to be close to the expected angle of response of the placed dredge material. This slope was maintained at the head of the bar as well (Encl 1).

b) Wave Conditions: The model was run for three sets of wave conditions representing swell, storm seas, and extreme storm seas. Case 1 was a swell represented with height (H) = 0.75 meters and period (T) = 14.4 seconds. These are long waves which occur at Norfolk at a frequency of 1.2 percent of the time. The second case was typical of a northeaster with H = 3 m and T=8 sec. This is a steep wave which has about 0.6 percent occurrence. The final case represents the extreme event with H= 4m and T= 12 seconds. Frequency of occurrence of this wave is 0.03 percent (Encl. 3). In all instances the incoming wave crest approached parallel to the bar crest and bottom contours.

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c) Model Parameters: In order to resolve the selected wave conditions the model grid spacing was selected as $\Delta X = \Delta Y = 8$ meters. This provided almost 9 points per wavelength in the shortest wave case. Similarly, the time step was chosen to be $\Delta T = 0.8$ seconds in order to properly simulate the wave translation. The model was run for 200 times steps, the time necessary for all transients and the first full wave to pass through the model.

4. SWELL WAVE RESULTS. Encl. 4 presents the results of the swell wave tests. The wave trains shown can be likened to an instantaneous onshore-offshore cross-section. The presence of the bar in this case causes a steepening of the waves as they traverse the bar with a resultant phase shift of about 0.15 wavelength or about 2.2 second lag. Any attenuation of wave height is not discernible after the passage of the wave over the bar. In a two-dimensional sense, the presence of the bar merely steepens the waves temporarily before they continue shoreward, phase shifted. Refraction effects are discussed later. Calculated maximum bottom velcities by stream function theory at the crest of the submerged bar are on the order of 50 cm/s. ≈ 1 kn.t

5. STORM WAVE RESULTS. Encl. 5 gives the results for the case of H = 3m and T=8 seconds. As in the swell wave case, the bar steepens the waves and causes a phase shift on the order of 2.2 seconds. This temporary shortening of the wavelength causes the wave to heighten to conserve energy. This higher wave then propagates shoreward with a phase shift as mentioned. The increased wave height in the barred case is approximately 0.4 meters or 13% of the wave height. Actually the same process occurs during the swell wave case, but it is not really large enough to be noticeable on the plot. Estimated bottom velocities using stream function theory are on the order of 150 cm/s. ~ 3 knots

6. EXTREME CASE. Encl. 6 details the results of waves having H = 4 m, T = 12s. As can be seen a similar phase shifting has occurred as was evidenced in the earlier cases. However, the results also indicate that this case is pushing the stability limits of the numerical scheme, and hence, cannot be considered reliable. Estimated maximum horizontal bottom velocities at the top of the bar in this case are around 230 cm/s. ~ 4.5 kn.b

7. REFRACTION. The phase difference between waves passing over the bar and those passing by either end will produce some refraction of the wave into the region in the lee of the submerged bar. Model simulation results show this refraction for the storm wave case, but the effect does not appear to be very significant. Since the model didn't continue to the shoreline, it is difficult to surmise if these refraction effects will have any impact on the shoreline. It is intuitively felt that any effect will be minor and without consequence.

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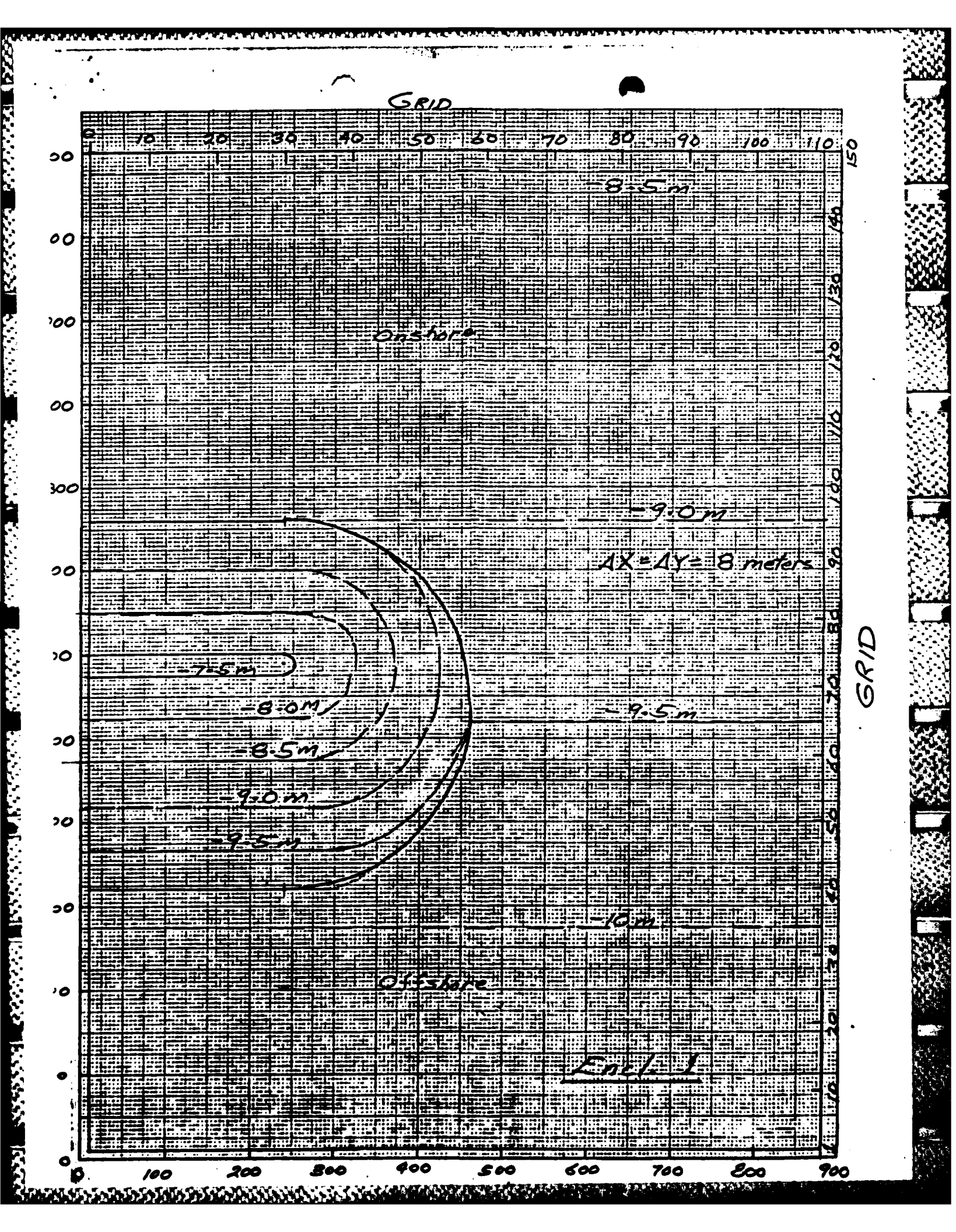
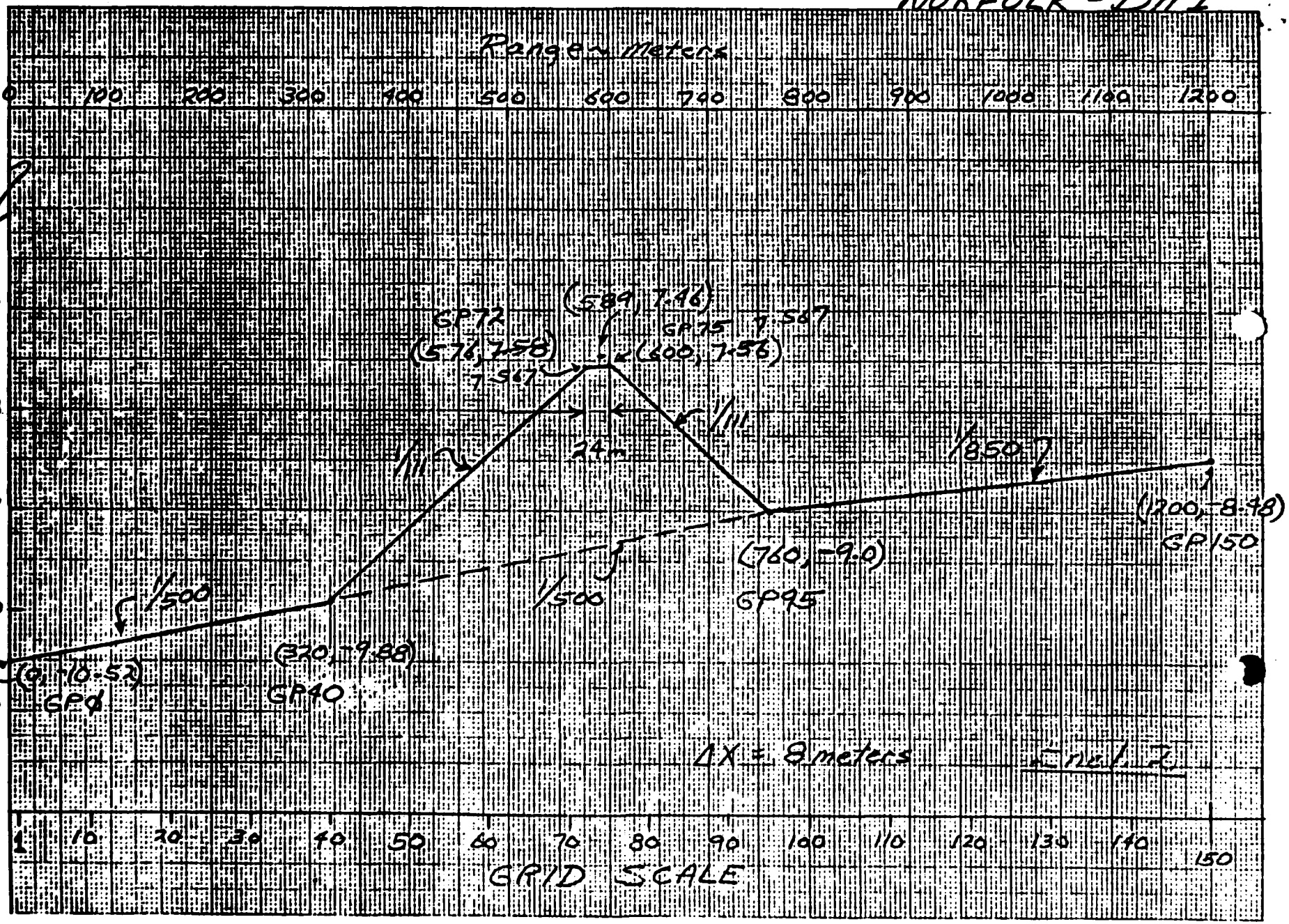
8. CONCLUSIONS. The selected wave cases run in the Model were chosen as being most likely to be affected by the presence of a submerged offshore bar. In all cases a phase lag develops as the wave passes over the bar, resulting in wave refraction around the ends of the bar. This refraction appears to be relatively minor with little noticeable effect on the adjacent shoreline. The estimated bottom velocities at the bar crest are well above that necessary for the initiation of sand transport, and a reworking of the bar material should be expected.

Steven A. Hughes

STEVEN A. HUGHES
Hydraulic Engineer
Coastal Oceanography Branch

CF:
Everts
Parker
Whalin


GRID
10
20
30
40
50
60
70
80
90
100
110
-8.5m
Onshore
-9.0m
ΔX = ΔY = 8 meters
-7.5m
-8.0m
-8.5m
-9.0m
-9.5m
-9.5m
-10m
Offshore
Encl. 1
GRID
100
200
300
400
500
600
700
800
900


NORFOLK - DHI
Range ~ meters
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Depth ~ meters
7
8
9
10
11
(589, 7.46)
GP72
(576, 7.58)
7.567
GP75
7.567
(600, 7.56)
1/11
24m
1/11
1/850
(1200, -8.48)
GP150
(760, -9.0)
GP95
1/500
1/500
(320, -9.89)
GP40
(0, -10.52)
GP0
ΔX = 8 meters
Ref. Pt.
1
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
GRID SCALE

Cape Henry, VA

Phase III

d = 10 meters

20 years of data

TATION: A3077

AZIMUTH(DEGREES)= 0. -

PERCENT OCCURRENCE(X 100) OF HEIGHT AN

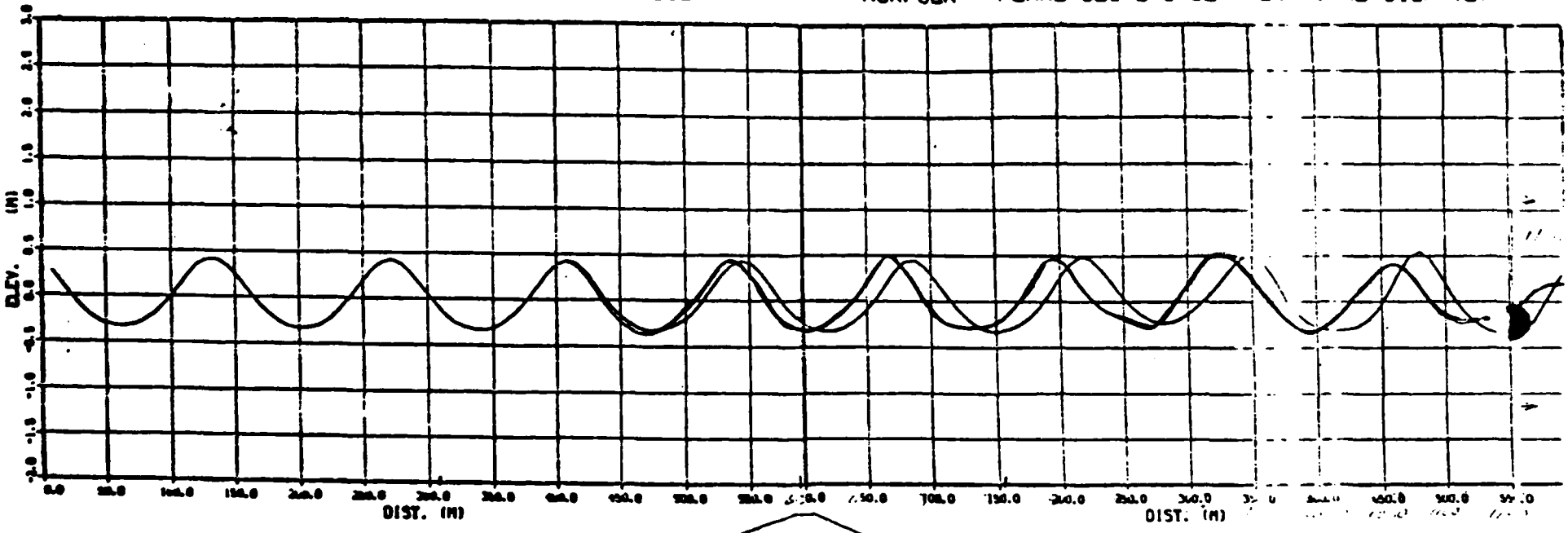
PERIOD(SECONDS)

EIGHT(METERS)	0. - 2.99	3.00- 4.99	5.00- 6.99	7.00- 8.99	9.00- 10.99	11.00- 12.99	13.00- 14.99	15.00- 16.99
0. - 0.49	1636	1821	1281	899	95	43	6	0
0.50- 0.99	0	812	420	965	259	47	123	0
1.00- 1.49	0	54	339	351	81	31	21	0
1.50- 1.99	0	0	110	214	43	13	1	0
2.00- 2.49	0	0	18	151	25	10	0	0
2.50- 2.99	0	0	0	56	20	4	0	0
3.00- 3.49	0	0	0	3	20	2	0	0
3.50- 3.99	0	0	0	0	3	1	0	0
4.00- 4.49	0	0	0	0	0	2	0	0
4.50- 4.99	0	0	0	0	0	0	0	0
5.00- 5.49	0	0	0	0	0	0	0	0
5.50- 5.99	0	0	0	0	0	0	0	0
6.00- 6.49	0	0	0	0	0	0	0	0
6.50- 6.99	0	0	0	0	0	0	0	0
7.00- 7.49	0	0	0	0	0	0	0	0
7.50- 7.99	0	0	0	0	0	0	0	0
8.00- 8.49	0	0	0	0	0	0	0	0
8.50- 8.99	0	0	0	0	0	0	0	0
9.00- 9.49	0	0	0	0	0	0	0	0
9.50- 9.99	0	0	0	0	0	0	0	0
10.00-10.49	0	0	0	0	0	0	0	0
10.50-10.99	0	0	0	0	0	0	0	0
11.00-11.49	0	0	0	0	0	0	0	0
11.50-11.99	0	0	0	0	0	0	0	0
12.00-12.49	0	0	0	0	0	0	0	0
12.50-12.99	0	0	0	0	0	0	0	0
13.00-13.49	0	0	0	0	0	0	0	0
13.50-13.99	0	0	0	0	0	0	0	0
14.00-14.49	0	0	0	0	0	0	0	0
14.50-14.99	0	0	0	0	0	0	0	0
TOTAL	1636	2687	2168	2639	546	153	151	0

Encl. 3

NORFOLK - PLANE SLOPE CASE - 200 TIME STEP

NORFOLK - PLANE SLOPE CASE - 200 TIME STEP (2)

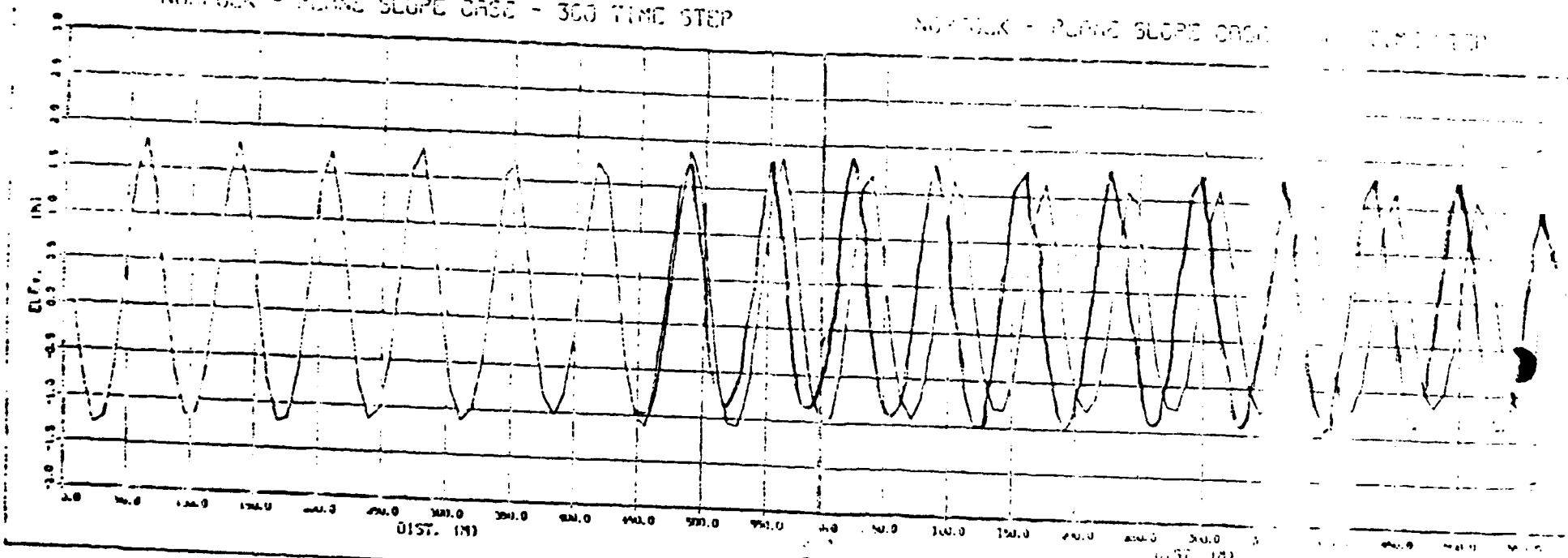


T = 14.4 sec
H = 0.25 m

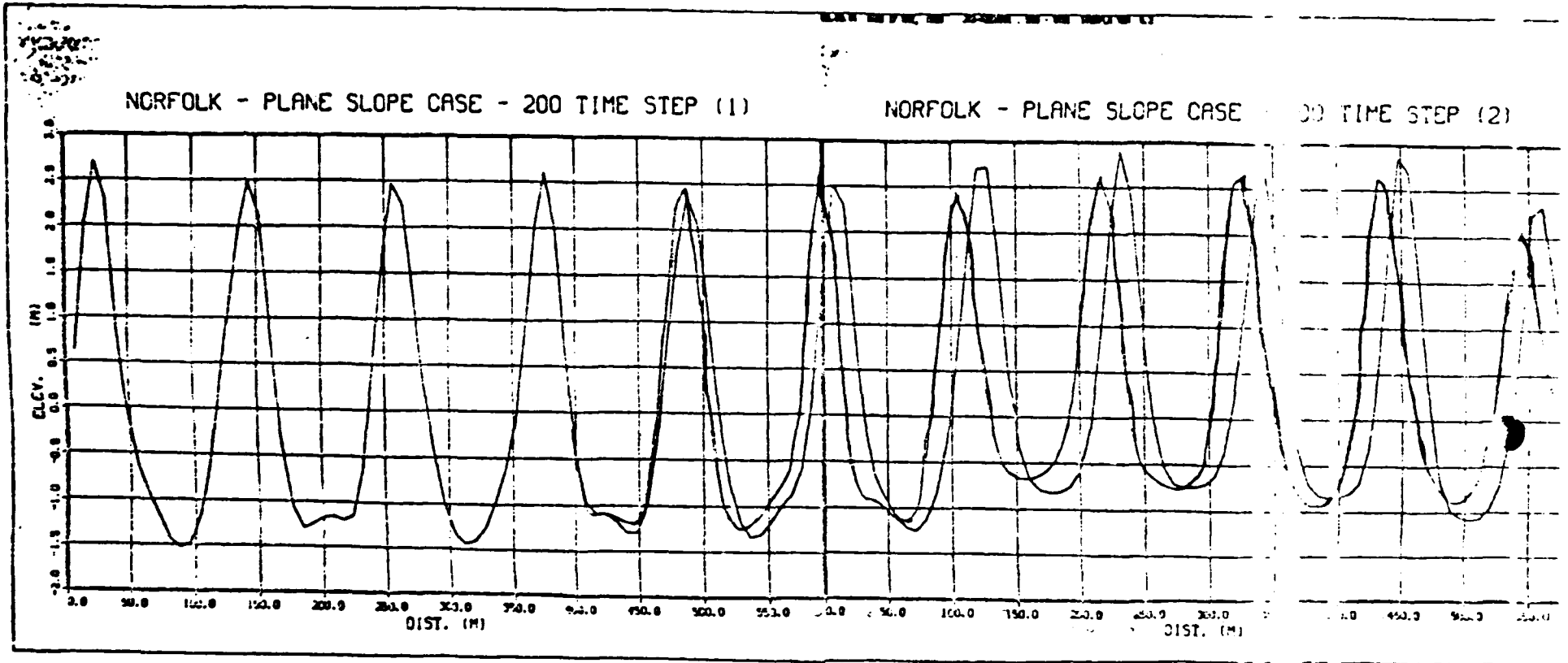
Relative Bar Location (NTS)

barred case

Enc. 4



Encl. 5


NORFOLK - PLANE SLOPE CASE - 200 TIME STEP (1)
NORFOLK - PLANE SLOPE CASE
TIME STEP (2)
ELEV. (M)
DIST. (M)
DIST. (M)

4m
125

Encl. 6

END

FILMED

DTIC